# New Treatments for Asthma

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## Objectives

After completing this article, readers should be able to:

1. Define asthma.
2. List conditions that mimic asthma.
3. Delineate the factors that predict the persistence of asthma.
4. Describe the objective measurements of pulmonary function required for evaluation and treatment of asthma.
5. Explain the role of anti-inflammatory medications in the management of persistent asthma.
6. Determine when a child should be referred to an asthma specialist.

## Epidemiology

Over the past 15 years, the number of people affected by asthma has more than doubled. Asthma is the most common pediatric chronic disease, afflicting nearly 5 million children younger than age 18 years in the United States. Asthma affects 1 of every 13 schoolchildren. Every year, asthma accounts for more than 3 million physician visits and 200,000 pediatric hospitalizations, with rates highest among African-American children. Asthma mortality nearly doubled between 1980 and 1993 (17 and 32 asthma deaths per 1 million population, respectively). More than 5,500 people die from asthma every year. Asthma is a major cause of school absenteeism, with an estimated 10 million missed schooldays each year. The economic impact of asthma is enormous, approaching $3 billion annually. This encompasses direct costs such as medical expenses and indirect costs of parents and caregivers taking time away from work to care for their ill children, which has been estimated at $1 billion anually.

Asthma severity is greater in urban minority populations, both African-American and Hispanic. Children living in inner cities often do not receive appropriate treatment to reduce their asthma severity and live in situations where it is difficult to control environmental exposures.

## Pathogenesis

Inflammation is present even in the airways of young patients who have mild asthma. A complex orchestration of inflammatory cells (eg, mast cells, eosinophils, T lymphocytes, and neutrophils), chemical mediators (eg, histamine, leukotrienes, platelet-activating factor, bradykinin), and chemotactic factors (eg, cytokines, eotaxin) results in the underlying inflammation found in asthmatic airways (Fig. 1). Inflammation of the airways contributes to airway hyperresponsiveness, which is characterized as the tendency for the airways to constrict in response to allergens, irritants, viral infections, and exercise. It also results in edema, increased mucus production in the lungs, an influx of inflammatory cells into the airway, and epithelial cell denudation. Chronic inflammation can lead to airway remodeling, which results from a proliferation of extracellular matrix proteins and vascular hyperplasia (Fig. 1). Chronic remodeling may lead to irreversible structural changes and a progressive loss of pulmonary function. Exactly when the child is most susceptible to remodeling and whether therapeutic intervention can prevent this is still unknown.

Airflow limitation due to the effects of airway inflammation leads to the respiratory

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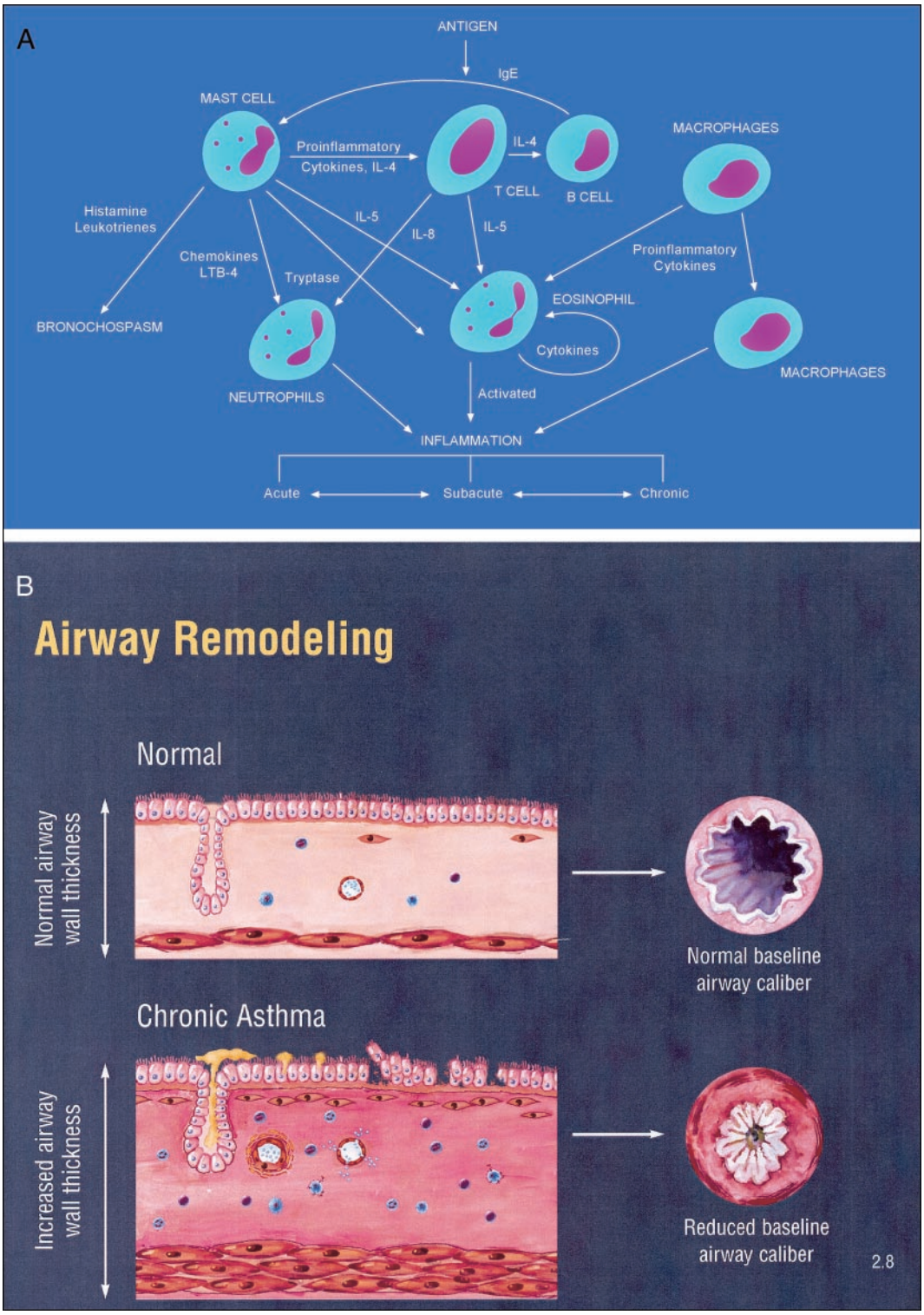



**Figure 1.** Airway inflammation in asthma. A. Cellular mechanisms involved in airway inflammation. B. Airway remodeling due to chronic airway inflammation. Ig=immunoglobulin, IL=interleukin.

**Table 1. Differential Diagnosis of Cough and Wheeze in Infants and Children**

| Upper Respiratory Tract | Middle Respiratory Tract | Lower Respiratory Tract |
|---|---|---|
| Allergic rhinitis | Bronchial stenosis | Asthma |
| Adenoid/tonsillar hypertrophy | Enlarged lymph nodes | Bronchiectasis |
| Foreign body | Epiglottitis | Bronchopulmonary dysplasia |
| Infectious rhinitis | Foreign body | *Chlamydia trachomatis* |
| Sinusitis | Laryngeal webs | Chronic aspiration |
| | Laryngomalacia | Cystic fibrosis |
| | Laryngotracheobronchitis | Foreign body |
| | Pertussis | Gastroesophageal reflux |
| | Toxic inhalation | Hyperventilation syndrome |
| | Tracheoesophageal fistula | Obliterative bronchiolitis |
| | Tracheal stenosis | Pulmonary hemosiderosis |
| | Tracheomalacia | Toxic inhalation |
| | Tumor | Tumor |
| | Vascular rings | Viral bronchiolitis |
| | Vocal cord dysfunction | |

Adapted from Lemanske RF Jr, Green CG. Asthma in infancy and childhood. In: Middleton E Jr, Reed CE, Ellis EF, et al, eds. *Allergy: Principles & Practice*. 5th ed. St. Louis, Mo: Mosby-Year Book, Inc; 1998:878.

symptoms of coughing, wheezing, shortness of breath, and chest tightness that are observed in children who suffer from asthma.

## Diagnosis

It can be difficult to diagnose asthma in children; asthma often is underdiagnosed among infants and young children who wheeze during respiratory infections. It also is important to recognize that cough and wheeze do not always reflect asthma. Care is needed to avoid prescribing inappropriate prolonged asthma medications. Other conditions that mimic asthma are shown in Table 1. For some children, symptoms of wheezing accompanying respiratory infections subside in the preschool years; other children develop persistent symptoms. However, the strongest predictor for wheezing developing into asthma is atopy. Approximately 70% to 90% of children who have asthma and are older than 5 years of age have positive allergy skin tests. Other predictive factors include parental history of asthma, peripheral blood eosinophilia, wheezing episodes apart from upper respiratory tract infections, and presence of atopic dermatitis or allergic rhinitis.

Three steps for diagnosing asthma are to obtain a careful history, perform a thorough physical examination, and objectively measure pulmonary function. The history should elicit the child's symptoms of coughing, wheezing, shortness of breath or rapid breathing, or chest tightness and the frequency and severity of such symptoms. Symptoms tend to occur or worsen at night, waking the child or parent. Asthma symptoms frequently are exacerbated by viral infections, exposure to allergens and irritants (smoke, strong odors and fumes), exercise, emotions, and changes in weather/humidity. A family history of allergy and asthma is a useful finding; allergic diseases tend to occur in families. On examination, physical findings may be subtle. Wheezing may not be present. Evidence of other atopic diseases such as eczema or allergic rhinitis can help guide the clinician to the correct diagnosis.

If possible to obtain, objective measurements of pulmonary function (spirometry) are essential to establish the diagnosis and treatment of asthma. Spirometry should be undertaken at the initial visit as well as at return visits to document attainment of "normal" pulmonary functions. Spirometry testing can help monitor the patient's response to the treatment plan, assess the degree of reversibility with optimal asthma management, and measure the severity of an asthma exacerbation. Spirometry should be obtained at least annually to ensure preservation of airway function, at visits where there are reports of pulmonary instability, and if there have been changes in the medication regimen. Children older than 5 years usually can perform spirometry maneuvers. Several practice sessions may be necessary for the younger child to master spirometry techniques.

Because atopy plays an important role in asthma persistence, allergy skin testing should be considered.

**Table 2. Controlling Factors Contributing to Asthma Severity**

| Major Indoor Triggers for Asthma | Suggestions for Reducing Exposure |
|---|---|
| Viral upper respiratory tract infections<br>Influenza | • Limit exposure to viral infections (ie, smaller size child care)<br>• Administer annual influenza shots to children who have persistent asthma (who are not allergic to eggs) |
| Tobacco smoke, wood smoke | • Do not smoke around the child or in child's home<br>• Help parents and caregivers quit smoking<br>• Eliminate use of wood stoves and fireplaces |
| Dust mites | Essential actions:<br>• Encase pillow, mattress, and box spring in allergen-impermeable encasement<br>• Wash bedding in hot water weekly<br>Desirable actions:<br>• Avoid sleeping or lying on upholstered furniture<br>• Minimize number of stuffed toys in child's bedroom<br>• Reduce indoor humidity to <50%<br>• If possible, remove carpets from bedroom and play areas; if not possible, vacuum frequently |
| Animal dander | • Remove the pet from the home or keep outdoors<br>• If removal is not acceptable:<br>—Keep pet out of bedroom<br>—Use filters on air ducts in child's room<br>—Wash pet weekly (although evidence to support the benefit of this action has not been firmly established) |
| Cockroach allergens | • Do not leave food or garbage exposed<br>• Use boric acid traps<br>• Reduce indoor humidity to <50%<br>• Fix leaky faucets, pipes |
| Indoor mold | • Fix leaky faucets, pipes<br>• Avoid vaporizers<br>• Reduce indoor humidity to <50% |

Adapted from American Academy of Allergy, Asthma & Immunology, Inc. *Pediatric Asthma: Promoting Best Practice*. Milwaukee, Wisc: American Academy of Allergy, Asthma, and Immunology, Inc; 1999:50.

A board-certified allergist offers the special skill of administering and interpreting skin tests to determine immediate hypersensitivity to aeroallergens. Studies have demonstrated that positive skin test results correlate strongly with bronchial allergen provocative challenges. In vitro tests, such as radioallergosorbent test and enzyme-linked immunosorbent assay, are other options to measure levels of antigen-specific immunoglobulin E. However, compared with skin testing, in vitro testing generally is not as sensitive in defining clinically pertinent allergens, is more expensive, and requires several days for results (compared with several minutes for skin tests).

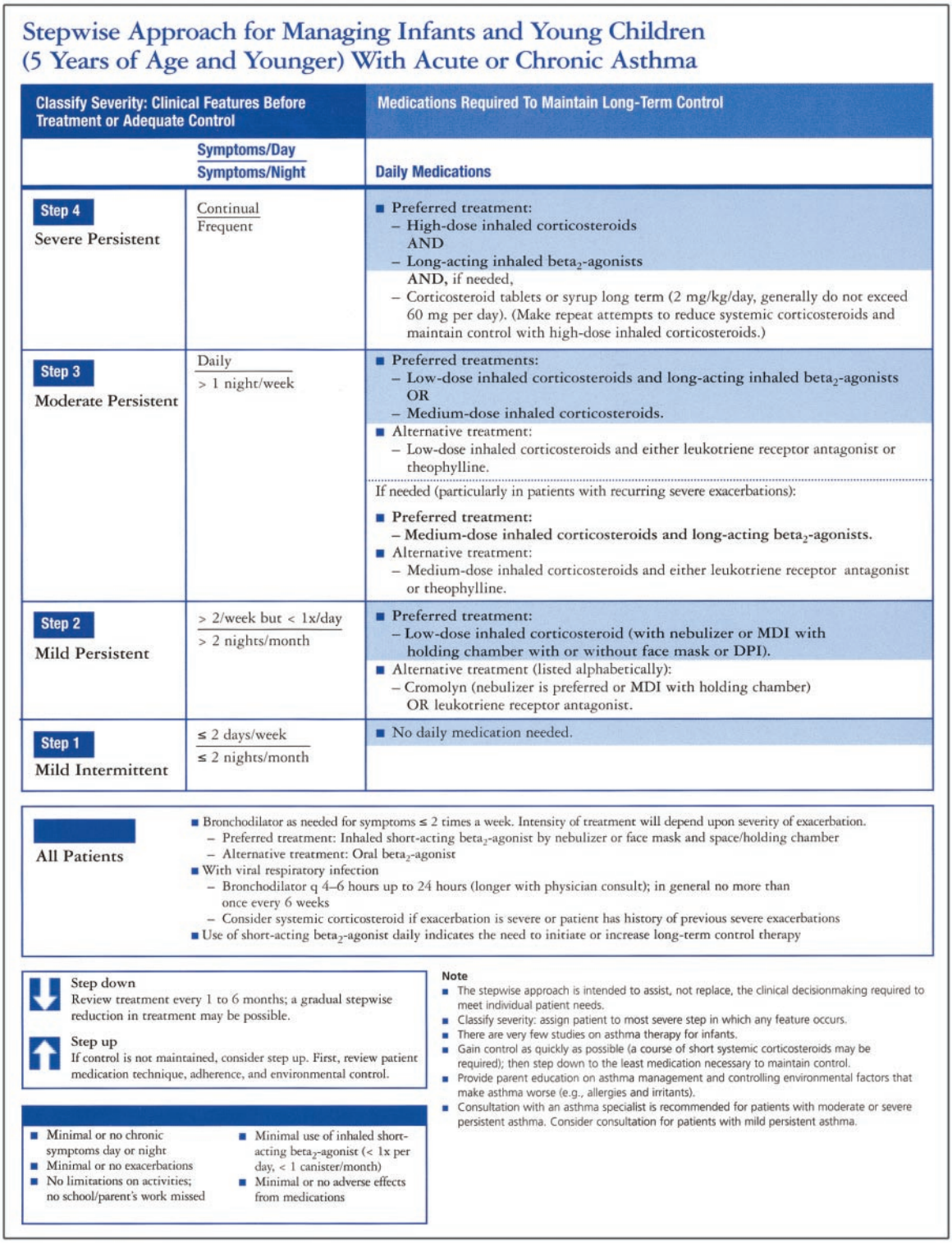
## Environmental Control

Optimal medical treatment of asthma is based on three key components: environmental control, pharmacologic therapy, and patient education, including acquisition of self-management skills.

Because children have a high incidence of allergy related to asthma, steps should be taken to minimize allergen exposure (Table 2). For all children who have asthma, common sense dictates that exposures to tobacco and wood smoke as well as viral infections be minimized.

## Pharmacologic Therapy

Current therapy is based on the concept that chronic inflammation is a fundamental feature of the disease. The National Asthma Education and Prevention Program recently published an update on classification and treatment based on asthma severity. The stepwise approach for management of infants and young children is shown in Figure 2 and for children 5 years of age and older is shown in Figure 3. A short-acting bronchodilator should be available for all children who have asthma. Intermittent asthma is defined as the presence of asthma symptoms less frequently than twice weekly. To determine if a child is having more persistent asthma, the "rule of twos"



## Stepwise Approach for Managing Infants and Young Children (5 Years of Age and Younger) With Acute or Chronic Asthma

| Classify Severity: Clinical Features Before Treatment or Adequate Control | Symptoms/Day<br>Symptoms/Night | Medications Required To Maintain Long-Term Control<br>Daily Medications |
|---|---|---|
| **Step 4**<br>Severe Persistent | Continual<br>Frequent | ■ Preferred treatment:<br>– High-dose inhaled corticosteroids<br>AND<br>– Long-acting inhaled beta$_2$-agonists<br>AND, if needed,<br>– Corticosteroid tablets or syrup long term (2 mg/kg/day, generally do not exceed 60 mg per day). (Make repeat attempts to reduce systemic corticosteroids and maintain control with high-dose inhaled corticosteroids.) |
| **Step 3**<br>Moderate Persistent | Daily<br>> 1 night/week | ■ Preferred treatments:<br>– Low-dose inhaled corticosteroids and long-acting inhaled beta$_2$-agonists<br>OR<br>– Medium-dose inhaled corticosteroids.<br>■ Alternative treatment:<br>– Low-dose inhaled corticosteroids and either leukotriene receptor antagonist or theophylline.<br>If needed (particularly in patients with recurring severe exacerbations):<br>■ Preferred treatment:<br>– Medium-dose inhaled corticosteroids and long-acting beta$_2$-agonists.<br>■ Alternative treatment:<br>– Medium-dose inhaled corticosteroids and either leukotriene receptor antagonist or theophylline. |
| **Step 2**<br>Mild Persistent | > 2/week but < 1x/day<br>> 2 nights/month | ■ Preferred treatment:<br>– Low-dose inhaled corticosteroid (with nebulizer or MDI with holding chamber with or without face mask or DPI).<br>■ Alternative treatment (listed alphabetically):<br>– Cromolyn (nebulizer is preferred or MDI with holding chamber)<br>OR leukotriene receptor antagonist. |
| **Step 1**<br>Mild Intermittent | ≤ 2 days/week<br>≤ 2 nights/month | ■ No daily medication needed. |

**All Patients**

- Bronchodilator as needed for symptoms ≤ 2 times a week. Intensity of treatment will depend upon severity of exacerbation.
  - Preferred treatment: Inhaled short-acting beta$_2$-agonist by nebulizer or face mask and space/holding chamber
  - Alternative treatment: Oral beta$_2$-agonist
- With viral respiratory infection
  - Bronchodilator q 4–6 hours up to 24 hours (longer with physician consult); in general no more than once every 6 weeks
  - Consider systemic corticosteroid if exacerbation is severe or patient has history of previous severe exacerbations
- Use of short-acting beta$_2$-agonist daily indicates the need to initiate or increase long-term control therapy

**Step down**
Review treatment every 1 to 6 months; a gradual stepwise reduction in treatment may be possible.

**Step up**
If control is not maintained, consider step up. First, review patient medication technique, adherence, and environmental control.

- Minimal or no chronic symptoms day or night
- Minimal or no exacerbations
- No limitations on activities; no school/parent's work missed
- Minimal use of inhaled short-acting beta$_2$-agonist (< 1x per day, < 1 canister/month)
- Minimal or no adverse effects from medications

**Note**

- The stepwise approach is intended to assist, not replace, the clinical decisionmaking required to meet individual patient needs.
- Classify severity: assign patient to most severe step in which any feature occurs.
- There are very few studies on asthma therapy for infants.
- Gain control as quickly as possible (a course of short systemic corticosteroids may be required); then step down to the least medication necessary to maintain control.
- Provide parent education on asthma management and controlling environmental factors that make asthma worse (e.g., allergies and irritants).
- Consultation with an asthma specialist is recommended for patients with moderate or severe persistent asthma. Consider consultation for patients with mild persistent asthma.

**Figure 2.** Stepwise approach for managing infants and young children ≤5 y who have acute or chronic asthma. From NHLBI, National Asthma Education and Prevention Program. *Expert Panel Report: Guidelines for the Diagnosis and Management of Asthma—Update on Selected Topics.* 2002.

## Stepwise Approach for Managing Asthma in Adults and Children Older Than 5 Years of Age: Treatment

| Classify Severity: Clinical Features Before Treatment or Adequate Control | Symptoms/Day<br>Symptoms/Night | PEF or $FEV_1$<br>PEF Variability | Medications Required To Maintain Long-Term Control<br>Daily Medications |
|---|---|---|---|
| **Step 4**<br>Severe Persistent | Continual<br>Frequent | ≤ 60%<br>> 30% | ■ Preferred treatment:<br>– High-dose inhaled corticosteroids<br>AND<br>– Long-acting inhaled $beta_2$-agonists<br>AND, if needed,<br>– Corticosteroid tablets or syrup long term (2 mg/kg/day, generally do not exceed 60 mg per day). (Make repeat attempts to reduce systemic corticosteroids and maintain control with high-dose inhaled corticosteroids.) |
| **Step 3**<br>Moderate Persistent | Daily<br>> 1 night/week | > 60% – < 80%<br>> 30% | ■ Preferred treatment:<br>– Low-to-medium dose inhaled corticosteroids and long-acting inhaled $beta_2$-agonists.<br>■ Alternative treatment (listed alphabetically):<br>– Increase inhaled corticosteroids within medium-dose range<br>OR<br>– Low-to-medium dose inhaled corticosteroids and either leukotriene modifier or theophylline.<br>If needed (particularly in patients with recurring severe exacerbations):<br>■ Preferred treatment:<br>– Increase inhaled corticosteroids within medium-dose range, and add long-acting inhaled $beta_2$-agonists.<br>■ Alternative treatment (listed alphabetically):<br>– Increase inhaled corticosteroids in medium-dose range, and add either leukotriene modifier or theophylline. |
| **Step 2**<br>Mild Persistent | > 2/week but < 1x/day<br>> 2 nights/month | ≥ 80%<br>20–30% | ■ Preferred treatment:<br>– Low-dose inhaled corticosteroids.<br>■ Alternative treatment (listed alphabetically): cromolyn,leukotriene modifier, nedocromil, OR sustained release theophylline to serum concentration of 5–15 mcg/mL. |
| **Step 1**<br>Mild Intermittent | ≤ 2 days/week<br>≤ 2 nights/month | ≥ 80%<br>< 20% | ■ No daily medication needed.<br>■ Severe exacerbations may occur, separated by long periods of normal lung function and no symptoms. A course of systemic corticosteroids is recommended. |

**All Patients**

- Short-acting bronchodilator: 2–4 puffs short-acting inhaled $beta_2$-agonists as needed for symptoms.
- Intensity of treatment will depend on severity of exacerbation; up to 3 treatments at 20-minute intervals or a single nebulizer treatment as needed. Course of systemic corticosteroids may be needed.
- Use of short-acting inhaled $beta_2$-agonists on a daily basis, or increasing use, indicates the need to initiate or increase long-term control therapy.

**Step down**
Review treatment every 1 to 6 months; a gradual stepwise reduction in treatment may be possible.

**Step up**
If control is not maintained, consider step up. First, review patient medication technique, adherence, and environmental control.

- Minimal or no chronic symptoms day or night
- Minimal or no exacerbations
- No limitations on activities; no school/work missed
- PEF > 80% of personal best
- Minimal use of inhaled short-acting $beta_2$-agonist (< 1x per day, < 1 canister/month)
- Minimal or no adverse effects from medications

**Note**

- The stepwise approach is meant to assist, not replace, the clinical decisionmaking required to meet individual patient needs.
- Classify severity: assign patient to most severe step in which any feature occurs (PEF is % of personal best; $FEV_1$ is % predicted).
- Gain control as quickly as possible (consider a short course of systemic corticosteroids); then step down to the least medication necessary to maintain control.
- Provide education on self-management and controlling environmental factors that make asthma worse (e.g., allergens and irritants).
- Refer to an asthma specialist if there are difficulties controlling asthma or if step 4 care is required. Referral may be considered if step 3 care is required.

**Figure 3.** Stepwise approach for managing asthma in adults and children >5 y. From NHLBI, National Asthma Education and Prevention Program. *Expert Panel Report: Guidelines for the Diagnosis and Management of Asthma—Update on Selected Topics.* 2002.

can be helpful. The presence of daytime symptoms two or more times per week or night-time awakening two or more times per month may indicate a need for daily controller medication that has anti-inflammatory activity. For infants and young children who have had three episodes of wheezing in the previous year as well as risk factors for the development of asthma (ie, parental asthma, peripheral blood eosinophilia, wheezing between upper respiratory tract infections, personal atopy) **or** who have severe exacerbations fewer than 6 weeks apart, long-term controller medications may be desirable.

The preferred first-line controller medication for children of all ages who have persistent asthma is inhaled corticosteroids. In clinical trials comparing inhaled corticosteroids with cromolyn, nedocromil, leukotriene modifiers, or theophylline, inhaled corticosteroids were the most effective medications in improving long-term asthma control. Low-dose inhaled corticosteroids are recommended for children who have mild persistent asthma. For children older than 5 years of age who have moderate persistent asthma, combining long-acting bronchodilators with low to medium doses of inhaled corticosteroids improves lung function and reduces rescue medication usage. The evidence for adding a leukotriene modifier or theophylline or for doubling the dose of corticosteroid is not as well supported by clinical studies. For children younger than 5 years of age who have moderate persistent asthma, medication combinations have not been as well studied. The preferred therapy is either a combination of low-dose inhaled corticosteroids and long-acting bronchodilators or medium doses of inhaled corticosteroids. High-dose inhaled corticosteroids and long-acting bronchodilators are the preferred therapies for children who have severe persistent asthma. The guidelines also recommend that patients be assessed every 1 to 6 months to determine whether medications should be reduced (step-down) or increased (step-up), depending on disease control.

Long-term controller medications are taken daily to achieve and maintain control of persistent asthma. Some controller medications, such as cromolyn, nedocromil, and theophylline, have been available for many years and will not be reviewed in this article. Discussion of the newer medications, including inhaled corticosteroids, leukotriene modifiers, and long-acting bronchodilators, follows.

## Inhaled Corticosteroids

Inhaled corticosteroids are the most effective anti-inflammatory medications for the treatment of chronic persistent asthma. Inhaled corticosteroids are available as metered-dose inhalers (MDI), dry powder inhalers (DPI), and nebulizer solutions. The inhaled corticosteroids available in the United States include beclomethasone, budesonide, flunisolide, fluticasone, and triamcinolone, with mometasone forthcoming. Clinical trials with the next generation of inhaled corticosteroids are proceeding.

The greatest concern of parents and physicians about these medications is the risk of systemic corticosteroid activity. In general, if the medications are used in doses of less than 400 mcg/day (beclomethasone equivalent), there is little risk of systemic effects.

Information about the effects of corticosteroids on linear growth is conflicting in the literature. Short-term studies suggest growth delay of about 1 cm/y. The reliability of this growth delay is tempered by the apparent similarity of heights compared with normal peers demonstrated in long-term studies. The Childhood Asthma Management Program (CAMP) trial provides the largest and longest double-blind, randomized trial of inhaled corticosteroid treatment compared with placebo in children as well as a cohort of children treated with nonsteroidal anti-inflammatory therapy (nedocromil). There was a 1.1-cm difference in growth between the children assigned to budesonide and those assigned to placebo that occurred as a result of a decrease in growth velocity. This reduction in growth velocity took place within the first year of steroid therapy and was not progressive thereafter. The CAMP Continuation Study is ongoing, and more information will be forthcoming about the growth of these children as they reach their adult heights. The practitioner must monitor for potential growth suppression in individual patients by regularly scheduled height measurements, preferably with a stadiometer. Rinsing the mouth after inhalation of corticosteroids and using spacers help to lessen local adverse effects of dysphonia and candidiasis as well as to decrease systemic absorption from the gastrointestinal tract. To minimize adverse effects, the goal is to use the lowest effective dose that controls the child's asthma.

## Leukotriene Modifiers

Leukotriene modifiers are a new class of oral daily-use asthma medication. Leukotrienes, synthesized via the arachidonic acid metabolism cascade, are potent mediators of inflammation and smooth muscle bronchoconstriction. Leukotriene modifiers have been designed to inhibit edema, mucus secretion, smooth muscle contraction, and eosinophil migration into the airways. There are two classes of leukotriene modifiers based on their

site of action: leukotriene synthesis inhibitors (eg, zileuton) and cysteinyl leukotriene receptor antagonists (eg, zafirlukast and montelukast). Zileuton is approved for use in children older than 12 years of age. It is used less commonly than other leukotriene modifiers because of a need to monitor liver enzymes regularly, the possibility of drug interactions, and an initial dosing regimen of four times per day. The leukotriene receptor antagonists have much wider appeal. Zafirlukast has been approved for children older than 7 years of age and is administered twice daily. Montelukast is dosed once daily at night as 4-mg or 5-mg chewable tablets for ages 2 to 5 years and 6 to 14 years, respectively. A 10-mg tablet is available for adolescents older than 15 years. Pediatric studies demonstrate the usefulness of leukotriene modifiers in mild asthma and the attenuation of exercise-induced bronchoconstriction. These agents also are useful as steroid-sparing agents for patients whose asthma is more difficult to control.

Although leukotriene modifiers are considered "alternative therapy" for long-term control in children who have mild persistent asthma, they are appealing because of their easy administration and excellent safety profile. In addition, these medications do not provoke "steroid phobia" in families or physicians, which can be a reason for the undertreatment of asthma with inhaled corticosteroids.

### Long-acting Beta-2 Agonists

Newly available long-acting beta-2 agonists include formoterol and salmeterol. These medications are administered twice daily and exhibit bronchodilatory effects for up to 12 hours. It is important to recognize that these agents do not have any significant anti-inflammatory effects. Studies have demonstrated that adding a long-acting bronchodilator to inhaled corticosteroid therapy is more beneficial than doubling the dose of inhaled corticosteroids. Formoterol, available in the DPI form, is approved for use in children older than 5 years for maintenance asthma therapy and for prevention of exercise-induced asthma among children older than 12 years. Formoterol has a rapid onset of action that is similar to albuterol (15 min) compared with a 30-minute onset of action for salmeterol. Salmeterol is available in the MDI form for children 12 years of age and older; the DPI form is approved for children 4 years of age and older.

In spring 2001, a fluticasone/salmeterol combination product, Advair® (GlaxoSmithKline), received United States Food and Drug Administration approval for children older than 12 years for maintenance treatment of asthma. It is available as a DPI in three doses, based on the amount of corticosteroid available (100 mcg, 250 mcg, or 500 mcg). Each of the strengths contains 50 mcg of salmeterol. Its advantages include possible improved compliance because it is administered as one puff twice daily and the combination of two potent asthma medications. Study trials for combination therapy for younger children are ongoing.

### Novel Therapies

With an improved understanding of the basic mechanisms of airway inflammation, future asthma treatment will target the components of the inflammatory cascade. Possibilities include anti-immunoglobulin E and anticytokine therapies. Research is preliminary, and time will tell whether these therapies will be a helpful addition to the physician's armamentarium.

### Other Therapies

The management of children in respiratory failure from status asthmaticus is beyond the scope of this article. Generally, medical therapy involves the use of frequent or continuous beta-2 agonist nebulization therapy and oral or intravenous corticosteroids. Chest physiotherapy can help move secretions to central airways, where cough can expel the secretions, and can be helpful in asthmatic patients who have coexisting chronic obstructive pulmonary disease or emphysema. Typically, these are not pediatric patients. Mucolytic agents, such as N-acetylcysteine, may induce bronchoconstriction and should be used with caution. Only when adequate mechanical ventilation is in progress should sedative, narcotic, or anxiolytic drugs be administered to the patient in status asthmaticus.

## Patient Education

Education plays an important role in helping asthmatic patients and their families adhere to the prescribed therapy and needs to begin at the time of diagnosis. Key educational messages include basic asthma facts, the role of medications, environmental control measures, monitoring skills to recognize the symptoms of asthma that indicate adequate or inadequate asthma control, and an asthma management plan for exacerbations as well as daily control. Absorbing such information can be overwhelming in a 15-minute appointment, but other health care team members and office staff can help reinforce the educational messages. Education is an ongoing process, and information needs to be adjusted appropriately for the child as he or she ages and for the family as they become more educated. Many outside resources can

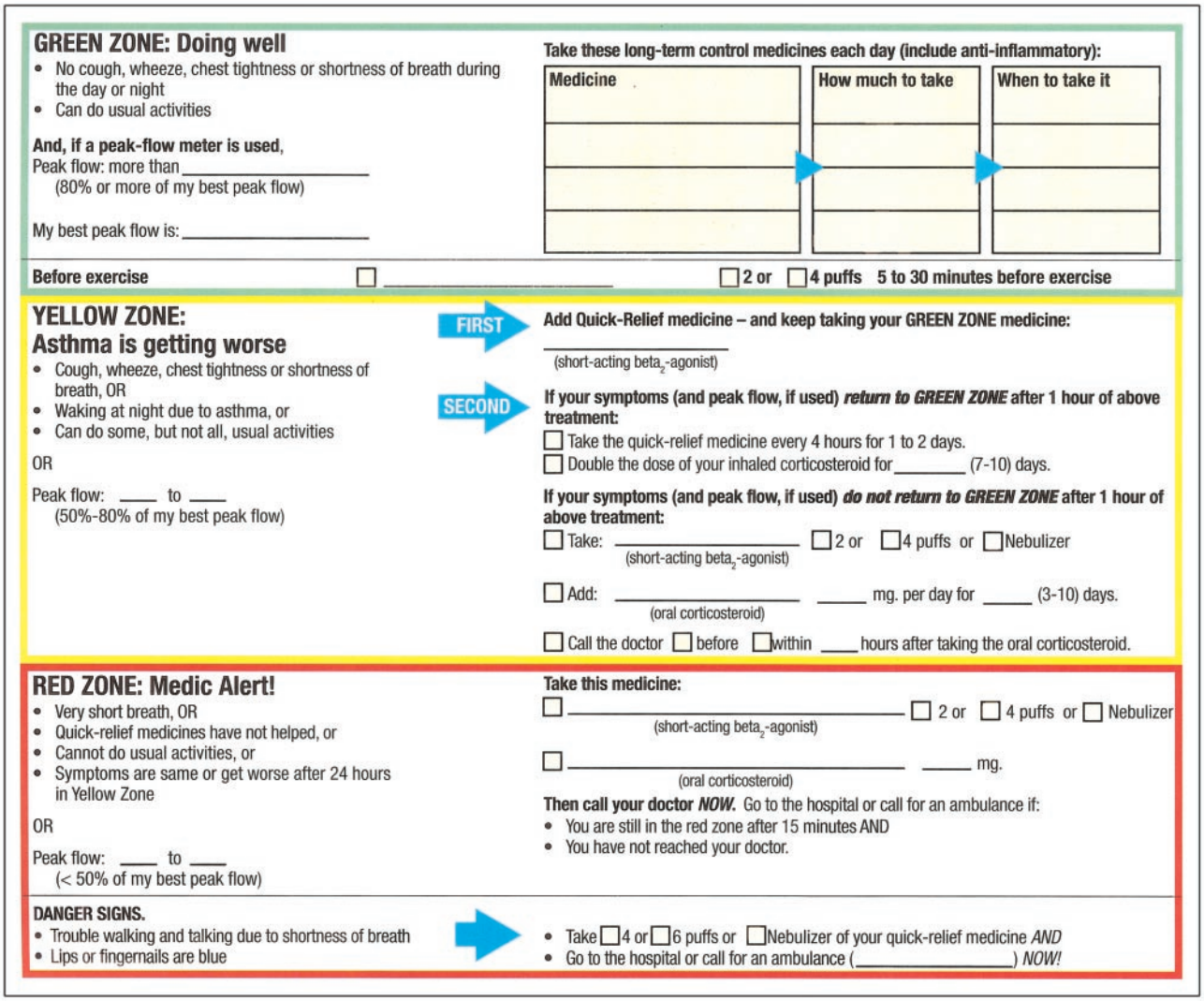



**Figure 4.** Sample asthma management plan for long-term control and for treating asthma exacerbations. Reprinted with permission from American Academy of Allergy, Asthma & Immunology, Inc. *Pediatric Asthma: Promoting Best Practice*, Milwaukee, Wisc: American Academy of Allergy, Asthma & Immunology, Inc; 1999.

provide additional educational services to families. The Asthma and Allergy Foundation of America (www.aafa.org), the American Lung Association (www2.lungusa.org), the Allergy and Asthma Network Mothers of Asthmatics (www.aanma.org), American Acadmey of Allergy, Asthma, and Immunology (www.aaaai.org), and American College of Allergy, Asthma, and Immunology (www.acaii.org) are excellent sources of information.

A key message for families is that children who have asthma should be seen not only when they are ill, but also when they are healthy. Regular office visits allow the health care team to review adherence to medication and control measures and to determine if medication doses need adjustment.

Families need to have an asthma management plan (Fig. 4) for daily care and for exacerbations. Peak flow monitoring is a self-assessment tool that encourages asthma management. Reliable measurements often can be obtained in children older than 5 years. Use of the peak flow meter is advisable for children who are "poor perceivers" of airway obstruction, who have moderate-to-severe asthma, or who have a history of severe exacerbations. Peak flow monitoring also can be useful for

**Table 3. Referral To An Asthma Specialist**

- Child has had a life-threatening asthma exacerbation.
- Goals of asthma therapy are not being met after 3 to 6 months of treatment; earlier if child appears unresponsive to treatment.
- Signs and symptoms are atypical. Consider other diagnoses.
- Other conditions complicate asthma or its diagnosis (eg, rhinitis, sinusitis, gastroesophageal reflux).
- Additional diagnostic testing is indicated (eg, pulmonary function testing, allergy skin testing).
- Child or family needs additional education and guidance on complications of therapy, problems with adherence, or avoidance of triggers.
- Child is being considered for immunotherapy.
- Child has severe persistent asthma.
- Child is younger than 3 years and has moderate or severe persistent asthma.
- Child has used prolonged courses of oral corticosteroids, high doses of inhaled corticosteroids, or more than two bursts of oral corticosteroids in 12 months.

Adapted from American Academy of Allergy, Asthma & Immunology, Inc. *Pediatric Asthma: Promoting Best Practice*. Milwaukee, Wisc: American Academy of Allergy, Asthma, and Immunology, Inc; 1999:80.

children recently diagnosed with asthma who are still learning to recognize asthma symptoms.

To use a peak flow meter, a child should be standing with the indicator placed at the bottom of the scale. The child must inhale deeply, place the device in the mouth, bite down on the mouthpiece, seal his or her lips around the mouthpiece, and blow out forcefully and rapidly. The indicator moves up the numeric scale. The peak expiratory flow rate (PEFR) is the highest number achieved. The test is repeated three times to obtain the best possible effort. Peak flow meters are available as low-range (measurement up to 300 L/s) and high-range (measurement up to 700 L/s). It is important to provide the appropriate range meter to obtain accurate measurements and to avoid discouraging the child whose blows barely move the indicator.

A child's personal best is the highest PEFR achieved over a 2-week period when stable. A written plan is based on the child's personal best. There are three PEFR zones, similar to a stoplight (Fig. 4). The green zone indicates a PEFR of 80% to 100% of the child's personal best value. In this zone, the child is likely asymptomatic and should continue with medications as usual. The yellow zone indicates a PEFR of 50% to 80% of the child's personal best value and generally coincides with the child having more asthma symptoms. Rescue medications such as albuterol are added to the therapy, and a phone call to the physician may be warranted if the peak flows do not return to the green zone within the next 24 to 48 hours or if asthma symptoms are increasing. The red zone indicates a PEFR below 50% and is a medical emergency. The rescue medication should be taken immediately. If the PEFR remains in the red zone or the child is experiencing significant airway compromise, a phone call to the physician or emergency care is needed.

## When to Refer

Guidelines for when a child should be referred to an asthma specialist are shown in Table 3. To optimize care of the child who has asthma, the specialist must work closely with the primary care physician.

## Suggested Reading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## PIR Quiz

Quiz also available online at www.pedsinreview.org.

1. The pathophysiologic change seen only as a result of chronic inflammation is:

   A. Airway constriction.
   B. Airway destruction.
   C. Airway edema.
   D. Airway hyperresponsiveness.
   E. Airway remodeling.

2. The *strongest* predictor for chronic wheezing progressing to asthma is:

   A. Allergic rhinitis.
   B. Atopy.
   C. Cough.
   D. Family history.
   E. Upper respiratory tract infection associated with wheezing.

3. The preferred first-line controller medication for children of all ages who have persistent asthma is:

   A. Cromolyn.
   B. Inhaled corticosteroids.
   C. Leukotriene modifiers.
   D. Short-acting bronchodilators.
   E. Theophylline.

4. An asthma management treatment plan is *best* managed using the patient's:

   A. Frequency of asthma exacerbations.
   B. Level of physical activity.
   C. Number of medications used.
   D. Peak expiratory flow rate.
   E. Perception of airway obstruction.